State of California **The Resources Agency**

Memorandum

To : Mr. James L. Welsh

Date : June 14, 1968

File No.:

Subject: Honey Lake Water Quality Investigation

Robert F. Clawson
From : **Department of Water Resources**

The Northern District's ground water data program detected increasing amounts of arsenic in various wells in Honey Lake Valley, Lassen County, last year. The Water Quality Unit of the Northern District initiated an investigation to define the area of impaired water and locate the possible sources of impairment. This memorandum report gives the results of that investigation.

The physical and cultural features of the Honey Lake area are described in the introduction to this report. The ground water quality problem is discussed in detail starting on page 8. The report concludes with the results and recommendations of the investigation.

The following plates are presented at the back of the report:

Plate	
1	Geology
2	Sulfate Contours
3	Chloride Contours
4	Arsenic Well Locations
5	Cross Section

A tabulation of analyses of samples are also included at the back of this report.

The investigation leading to this report was conducted by Bruce Wormald, Associate Engineer, under the direction of Robert F. Clawson, Senior Engineer. William T. Rodriguez, Water Resources Technician I, Peter S. Freeman, Engineering Aid II, and Jon Anderson, Engineering Student Trainee, assisted in the investigation.

APPROVED:

Robert E. Foley Acting D.E.
~~Gordon W. Dukleth~~

Date 6/20/68

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INTRODUCTION

In January of 1967 the Department's monitoring program detected arsenic in excess of 0.05 ppm permitted by the United States Public Health Service drinking water standards in several wells in Honey Lake Valley. An investigation of the area consisting of a sampling program and a study of local geologic conditions to define the extent of impaired ground water and determine the possible source of impairment was initiated. Recommendations for action are included in this report. Also changes in the present monitoring program were made where it is felt that more adequate and pertinent data would be obtained. The State Bureau of Sanitary Engineering and the Lassen County Health Department were very helpful during the investigation.

Other Investigations and Reports

Bulletin No. 98, "Northeastern Counties Ground Water Investigation", and an office report, "Water Quality Investigation - Honey Lake and Willow Creek Valleys", are two previous studies of the ground water conditions and geologic setting of the area.

The reports provided valuable background and historic data on the area. Bulletin No. 98 and the Division of Mines Westwood Sheet of the geologic map of California provided geological information.

Area of Investigation

The investigation was confined to the western half of Honey Lake Valley, an interior basin located in northeastern California bordering Nevada. It excluded Long Valley draining into Honey Lake and the eastern portion of Honey Lake Valley extending into Nevada. Specific emphasis

HONEY LAKE VALLEY
WATER QUALITY INVESTIGATION

LOCATION MAP

SCALE OF MILES
0 40 80

was directed to the area north of Honey Lake located between Susanville and Amedee Hot Springs (Figure 1).

Culture

Honey Lake Valley is principally an agricultural area. The most extensive use of land is for stock raising and irrigated pasture. Susanville, located at the western end of the valley, is the principal commercial center for the area. There are several lumber mills located close to Susanville, the well timbered surrounding mountains providing an ample source of supply. There is a military ordnance depot at Herlong southeast of Honey Lake. A branch line of the Southern Pacific Railroad passes through the valley along the northern edge. The Department of Corrections maintains a penal institution about 7 miles east of Susanville. The population of Susanville is 6,900 and that of Honey Lake Valley about 10,000.

Climate

The climate of the valley floor is semi-arid. Rainfall averages 8 to 10 inches a year; however, precipitation ranges up to 36 inches a year in the surrounding mountains. Most of the precipitation occurs between November and April, although thundershowers can occur during the summer months. Summers are mild and dry; winters are cold and wet.

Topography

Honey Lake Valley is in the southeastern part of Lassen County. It is part of the Basin Range Geomorphic Province. The valley floor is at an elevation of 4,000 feet. The Diamond Mountains, which rise abruptly from the valley floor to 7,700 feet, form the southern and western perimeter of the valley. The northern edge is bounded by a series of mountains which range in elevation from 5,800 to 7,500 feet. The Susan River, Willow Creek, and Long Creek are the three principal drainages entering the valley. They terminate in the playa lake (Honey Lake) which has formed on the valley floor. There are numerous other small creeks and streams which percolate into the alluvium forming the valley floor or terminate in Honey Lake.

Geology

Honey Lake Valley is part of the Basin Range Geomorphic Province which extends into California along its western perimeter. It is bounded on the north by the Modoc plateau and on the southwest by the Sierra Nevada Geomorphic Province. The valley is wedge-shaped with Susanville located in the apex of the wedge.

The Diamond Mountains are a tilted block of granitic rock and form the northern edge of the Sierra Nevada batholith. The steep western face of the mountains is the old eroded surface of a steeply dipping normal fault with the valley floor forming the downthrown side. Alluvial fans have formed in the mouths of drainages at the base of the mountains, and alluvial terraces representing the nearshore deposits of Pleistocene Lake Lahontan are exposed along the base of the mountains.

Bald Mountain, a knoll of Tertiary volcanics, protrudes through the valley floor northwest of Honey Lake; its base is surrounded by terrace deposits.

The mountains along the northern edge of the valley are composed of Tertiary volcanic intrusives. They form a series of individual peaks separated by broad valleys, such as Willow Creek Valley, which are filled with Recent lava. Faulting is in evidence along the mountain front with concealed faults probably existing under the lake sediments forming the valley floor.

Recent alluvium covers most of the valley floor between Honey Lake and Susanville. The alluvium generally consists of unconsolidated sand and silt with some lenses of clay and gravel. Recent lake deposits are exposed around the western edge of Honey Lake and underlie Recent alluvium. The deposits consist of silt, clay and organic muck; they also contain occasional stringers of salt and extensive sandy zones. These lake deposits can range up to 5,000 feet in thickness and constitute most of the material filling the basin; however, the actual depth to bedrock in the central portion of the valley is not known.

The major structural features of Honey Lake Valley are the multitude of major and minor faults (Plate 1). These faults parallel the mountains defining the basin. Along the northern edge of the valley the faults trend east-west and along the south western edge the faults trend northwest-southeast. Many of the fault traces have been buried by sediments during the evolution of the present physiography. A fault along the southern edge of Bald Mountain probably extends around the eastern end of the hill. There is a possibility that a branch of this fault extends across the valley floor parallel to the northern edge of Honey Lake and through the town of Wendel (Plate 1).

GROUND WATER

Surface water falling on the drainages which flow into Honey Lake Valley, or on the valley itself, either percolates into the ground or drains into Honey Lake. The coarser gravels which form the alluvial fans, terraces, and near-shore deposits interfinger with the finer material forming the lake sediments and serve as the principal recharge areas to the basin.

Ground water levels vary from 5 to 50 feet in the valley. The Department's monitoring program indicates that there has been no definite trend in ground water levels, and that the water table has remained essentially static for the last 10 years. Local differences in water level measurements are probably caused by slight differences in the permeability of aquifers, both vertically and laterally, which are penetrated by wells of various depths. The amount of pumping and the time of the year when the pumping occurs also affect the water table locally. Monitored wells show a seasonal cycle. The ground water gradient within the valley is from the perimeter of the valley toward Honey Lake. Ground water levels in wells along the valley perimeter are generally 25 to 50 feet below the surface, while on the valley floor they range from 5 to 12 feet below ground surface.

There are two hot springs in the area of study. Wendel Hot Springs, located north of Honey Lake (T29N, R15E, 29 MDB&M), is probably located along a buried fault zone extending across the valley from Bald Mountain to Wendel Canyon. Calcareous tuffa mounds to the northeast indicate that the springs have been migrating along this possible fault zone in a southwesterly direction. Amedee Hot Springs is located on the eastern edge of Honey Lake and is coincident with the extension of Amedee fault which is represented by the fault scarp forming the eastern side of Wendel Canyon.

The overflow from these springs drains into Honey Lake. A well drilled by the Morman Church south of Susanville has hot water and is used for heating the church. There were reports of another hot water well in the area south of Susanville, but it could not be located. This occurrence of hot water indicates that there may be some recharge to the ground water basin from magmatic sources.

"Magmatic" is a term used throughout this report and refers to waters that are derived from molten igneous rock or magma.

Ground Water Quality

Ground water in Honey Lake basin is sodium bicarbonate in character; however, there are zones with high concentrations of chloride and sulfate ions which modify the character of the ground water. Analyses of surface waters draining into the basin show that they are either sodium, calcium, or magnesium bicarbonate in character and reflect the surrounding terrain over which they flow. The calcium and magnesium are generally replaced by the more soluable sodium ions upon reaching the basin. Two wells, T28N/R13E/2P1 and T29N/R13E/21M1, were calcium-magnesium in character. Honey Lake, a playa lake, is probably representative of the various characters of ground water found in the basin. The results of three analyses from the lake are shown in Table 1. Table 2 shows the results of analyses from samples collected in Honey Lake Valley.

TABLE 1

HONEY LAKE ANALYSES
MAJOR CONSTITUENTS*

	Anions				Cations		
	9-16-53	5-4-54	8-18-67		9-16-53	5-4-54	8-18-67
Bicarbonate	8.8	10.39	10.16	Calcium	.40	.47	
Sulfate	3.6	4.48	4.04	Magnesium	.44	.24	
Chloride	5.57	6.83	7.62	Sodium	18.96	22.70	
				Potassium	.74	.79	
				Minor Constituents*			
				Iron	1.8	0.56	
				Aluminum	0.23	0.07	
				Arsenic	0.08	0.13	0.12
				Zinc	0.03	0.03	

*Major constituents given in equivalents per million, minor constituents given in parts per million.

These analyses illustrate that the character of the water is sodium bicarbonate; however, there are significant amounts of sulfate and chloride ions. The arsenic in the lake is also reflective of the arsenic discharged by Wendel and Amedee Hot Springs. The overflow from these springs drains into Honey Lake. Plates 2 and 3 show lines of equal sulfate and chloride concentration respectively. Although the lines have been plotted irrespective of the depth of well or perforations, they illustrate the wide variation in water quality throughout the valley floor.

There is a series of eight wells along the northern edge of the valley whose waters contain 30 percent or more sulfate anions. The water in well No. T29N/R12E/4G1 and Wendel and Amedee Hot Springs water is sodium sulfate in character. All of the wells, and Wendel Hot Springs, lie along the trace of Lichfield fault (Plate 2). Another area where wells have a high concentration of sulfate is just north of Bald Mountain. Well No. T29N/R14E/19A2 has water of sodium sulfate-bicarbonate character and five other wells in the vicinity had sulfate concentrations exceeding 20 percent of total anions. These wells are close to the trace of a suspected concealed fault along the north side of Bald Mountain striking east-west.

Plate 3, which shows lines of equal chloride concentration, indicates that there are two dissimilar sources contributing to high chloride waters. There are four wells in the northwest corner of the valley with percentage reaction values of chloride ranging from 20 to 25 percent. Well No. T29N/R15E/18J2 had a chloride concentration of 65 percent and both hot springs (Wendel and Amedee) were close to 40 percent chloride. The locations of these wells in relation to the Lichfield fault and the evidence from the hot springs indicates that a considerable amount of ground water in this area is affected by magmatic sources. There is an area just north of Honey Lake in the northeast corner of T28N/R14E with very high chloride concentrations. These wells are probably drawing water from lacustrian sediments of an ancient playa lake similar to Honey Lake. These sediments probably contain salt which has been redissolved and is now contributing to the high chloride concentration from the wells. Well No. T28N/R14E/2Q1 had a percentage reactance value of chloride of 74 and Honey Lake is 28 percent at present.

Wells With Arsenic. Wells with arsenic are confined to the part of the valley north of Honey Lake and Bald Mountain (Plate 4). Several of the wells lie along the projected trace of Lichfield fault. Another group of wells is located in the vicinity of Standish. The wells along the northern edge of the valley contained arsenic values up to 0.05 ppm. No correlation was established between depth, temperature and any other constituent. The hot water in well No. T29N/R12E/5E1 had no arsenic and well No. T29N/R14E/20C2 had 0.57 ppm arsenic and a temperature of 54°F. Excluding the hot springs and hot water wells, the median temperature of ground water in 29 wells in the area was 58°F. No definite correlation could be established between arsenic and any other particular constituent. Boron, fluoride, or other trace elements may be present, but their concentration does not appear to correlate with the concentration of arsenic in water from wells. The cross-section (Plate 5) paralleling the trace of Lichfield fault illustrates this.

There is a group of wells in the vicinity of Standish with very high concentrations of arsenic. One well (T29N/R14E/17Q1) had a 2.0 ppm of arsenic and a check sample run by the California Bureau of Sanitary Engineering showed 2.6 ppm of arsenic. There were six wells in the area with arsenic concentrations exceeding 0.25 ppm. There were no logs available, but all the wells in question were reported to be less than 100 feet deep and used for domestic purposes. The wells are confined to Sections 17 through 20, T29N/R14E, and are close to the projected trace of the concealed fault on the north side of Bald Mountain.

The fault strikes northwest-southeast in this area and cuts diagonally through the four sections (Plate 1). The arsenic is probably the result of magmatic waters moving into the ground water body along this structural zone. These magmatic sources are probably located along the fault and have built up their own channels through deposition from their own highly mineralized waters. As the mineralized waters build up a channel toward the surface, the decrease in hydrostatic pressure permits the water to flow laterally where it is pumped from wells. The high percentage of sulfate encountered in water from wells in this area similar to those wells located along the Lichfield fault is further evidence that there is a concealed source of magnatic water which is degrading the ground water in the area.

Hot Springs. The evidence obtained from hot springs, the high concentrations of chlorides, and sulfates indicate a magmatic source for arsenic found in waters in the basin. The magmatic waters are mixed with meteoric water at depth. There are probably numerous springs along the Lichfield fault zone discharging into the sediments at various depths and the magmatic water itself is of varying composition. The concentration of arsenic in water from wells in this area varies from a trace to 0.06 ppm. The exceptions to this are Wendel and Amedee Hot Springs which have arsenic concentrations of 0.22 and 0.19 ppm. This is to be expected since this water from these springs is probably magmatic with a minimum amount of dilution from meteoric sources.

FINDINGS AND CONCLUSIONS

Honey Lake Valley is a closed basin and water leaves the basin through evapotranspiration. The character and chemistry of the ground water is reflective of the geological characteristics which have shaped the valley.

The ground water is generally sodium bicarbonate in character. Because there is no drainage, salts have accumulated in the basin. In local areas, high concentrations of chlorides are encountered and in the northern part of T28N/R14E one well contains water definitely sodium chloride in character.

The tectonic history of the area, the hot springs, and the hot water wells south of Susanville, all indicate that there could be a considerable amount of recharge to the ground water body from magmatic sources. These magmatic waters could be responsible for changes in the character, chemistry, and thermal characteristics of the ground water. This is illustrated in the lines of equal sulfate concentration shown on Plate 2.

The arsenic encountered in certain wells in the valley is probably the result of underground mineralized water migrating into the ground water body. The arsenic content in the water from Wendel and Amedee Hot Springs and the fact that the majority of wells which contained arsenic in their waters are located along the traces of concealed faults indicates that the arsenic is of magmatic origin. With the exception of those wells in the vicinity of Standish, hydrostatic pressure and dilution of the initial source prevent the arsenic levels from exceeding 0.05 ppm.

Those wells near Standish whose waters have arsenic concentrations ranging up to 2.0 ppm are probably also fed by underground magmatic sources; however, the sources are probably relatively near the surface. Depth to bedrock is probably less and the amount of dilution by the meteoric ground water is less than in the deeper parts of the basin. Any underground source would probably have a higher concentration of arsenic than either Wendel or Amedee Hot Springs where meteoric waters are mixed, heated and discharged along with the magmatic waters.

Mr. Donald Hill, the Lassen County Agricultural Commissioner, investigated the possibility of surface application of arsenical compounds for agricultural purposes. He stated that he could find no extensive use of arsenic for agricultural or stock raising purposes over the past twenty years. It is doubtful if any individual use of arsenic for local weed or pest control could account for the increase shown in the wells around Standish.

RESULTS OF INVESTIGATION

Residents using wells with high arsenic content were advised of the situation.

The Lassen County Health Department and the California Bureau of Sanitary Engineering were contacted and are conducting a survey in the area surrounding Standish to determine the exact extent of arsenic degradation.

The Department of Water Resources Operations Section has added well No. T29N/R14E/17Q1 to their monitoring program and will make a complete mineral analysis.

RECOMMENDATIONS

Wells used for domestic purposes should be deepened and adequately sealed for 100 to 150 feet below surface to prevent degradation of well water by the near surface ground water which contains arsenic.

The Northern District should undertake a follow up investigation in two years in the critical area around Standish to determine if the problem has become aggravated or not.

MINERAL ANALYSES OF GROUND WATER

HONEY LAKE VALLEY WATER QUALITY INVESTIGATION

Owner and use	State well number and other number	Date sampled	Temp in °F	Specific conductance (micromhos at 25° C)	pH	Mineral constituents in parts per million / equivalents per million													Total dissolved solids in ppm [a]	Percent sodium	Hardness as $CaCO_3$		Analyzed by [b]
						Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents			Total ppm	N.C. ppm	
Richard Slaughter Domestic & Commercial	27N/14E-26E1	8-24-66		194										14		0.0		Mn=0.00 As=0.00 Pb=0.00	125				
C.L. Newkirk Domestic	28N/13E-2Q1	2-14-67	58.2	515	7.8	36	22	39	6.7	0	304	6.9	2.1	7.3		0.0		As=0.00	314		182	0	
Calif. Dept. of Fish & Game Irrigation	28N/14E-2G1	8-22-57	56	1550	8.3	46 2.30	20 1.62	256 11.14	6.7 0.17	0 0.00	344 5.64	103 2.14	265 7.47	3.8 0.06	0.5 0.03	0.50	43		913	73	196	0	
		9-8-59	55	1320	8.4	33 1.65	15 1.25	234 10.18	6.8 0.17	14 0.47	328 5.38	94 1.96	210 5.92	2.0 0.03	0.4 0.02	0.00	49	Fe=0.07 Al=0.05					
		2-15-67	53	2460	8.2					0	483		401					As=0.03	1700*		277	0	
Calif. Dept. of Fish & Game Irrigation	28N/14E-2Q1	11-22-55	56	2070	7.2	88 4.39	40 3.25	256 11.14	14 0.36	0 0.00	282 4.62	32 0.67	515 14.52	1.3 0.02	0.1 0.01	0.35	50		1140	58	382	151	
		9-8-59	58	2160	7.7	101 5.04	45 3.68	257 11.18	14 0.36	0 0.00	282 4.62	13 0.27	550 15.51	0.9 0.01	0.1 0.01	0.20	51	Fe=0.23 Al=0.24 Mn=0.36 Cu=0.08 Zn=0.04 As=0.12	1170	55	436	205	
Honey Lake Surface Sample	28N/14E-17R1	8-18-67	95.5	2270	8.4					4	620	194	270								57		
Tanner Ranch Domestic	28N/15E-6K1	7-10-58	59	1630	8.4	76 3.79	42 3.44	246 10.70	6.0 0.15	15 0.50	516 8.46	285 5.93	122 3.44	0.6 0.01	0.9 0.05	0.46	31	Fe=0.0	1080	59	362	0	
		9-8-59	54	774	8.2	25 1.25	13 1.05	143 6.22	3.0 0.08	0 0.00	428 7.01	66 1.37	20 0.56	0.0 0.00	0.2 0.01	0.60	38	Al=0.23 Cu=0.02 Zn=0.23 As=0.02	520	72	115	0	
Amedee Hot Springs	28N/16E-8B1	2-15-67	217.0	1290	8.6	16 0.80	0.5 0.04	238 10.35	6.0 0.15	11 0.37	25 0.41	303 6.31	160 4.51	0.5 0.01		3.7			948		42	4	
Abraham Jensen Irrigation	29N/12E-3E4	7-10-58	62	479	7.2	22 1.10	10 0.82	58 2.52	3.7 0.09	0 0.00	95 1.56	91 1.86	38 1.07	0.0 0.00	0.3 0.02	0.60	52	Fe=0.92	323	56	96	18	

*T.D.S. Computed from Specific Conductance

a. Determined by addition of constituents unless otherwise noted

b. Analysis by indicated laboratory:
U.S. Geological Survey, Quality of Water Branch (U.S.G.S.)
State Department of Water Resources (D.W.R.)

MINERAL ANALYSES OF GROUND WATER

HONEY LAKE VALLEY WATER QUALITY INVESTIGATION

Owner and use	State well number and other number	Date sampled	Temp in °F	Specific conductance (micromhos at 25° C)	pH	Mineral constituents in parts per million / equivalents per million: Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents	Total[a] dissolved solids in ppm	Per cent sodium	Hardness as $CaCO_3$: Total ppm	N.C. ppm	Analyzed by[b]
Fruit Growers Supply Industrial	29N/12E-4G1	6-12-58	75	590	7.9	13/0.65	2.2/0.18	135/5.86	4.4/0.11	0/0.00	88/1.44	177/3.67	61/1.72	0.0/0.00	1.8/0.09	1.6	36	Fe=0.00	473	86	41	0	
		9-9-59	74	679	8.2	13/0.65	2.8/0.23	117/5.09	3.6/0.09	0/0.00	92/1.51	140/2.91	56/1.58	0.9/0.01	1.5/0.08	1.4	37	Al=0.10 As=0.01	418	84	44	0	
		8-25-66		720														As=0.02 Mn=0.05	500*				
		2-14-67	71.5	874	8.1					0	196		62					As=0.02	600*		130		
Mormon Church Heating	29N/12E-5E1	6-67	126.0	297	7.7	9.5/0.47	0.6/0.05	56/2.44	0.9/0.02	0/0.00	143/2.34	20/0.42	5.9/0.17	0.3/0.00		0.2		Al=0.08 Fe=0.20 Cu=0.04 Pb=0.00 Mn=0.02 Zn=0.00 As=0.01					
MacDonald Domestic	29N/12E-5R1	2-16-67	55.6	203	8.1	18	7.0	12	4.3	0	126	4.8	1.4	1.9		0.0		As=0.00	119		74	0	
Johnston Ranch Domestic	29N/13E-1N1	6-12-58	60	480	7.6	3.9/0.19	1.0/0.08	122/5.31	5.2/0.13	0/0.00	183/3.00	69/1.44	22/0.62	32/0.52	0.9/0.05	0.44	65	Fe=0.00	410	93	14	0	
		9-8-59	60	595	8.2	4.8/0.24	0.7/0.06	125/5.44	5.6/0.14	0/0.00	206/3.38	74/1.54	20/0.56	22/0.35	1.2/0.06	0.80	68		423	93	15	0	
		8-23-66		628											0.5	0.7		As=0.07	430*				
		2-15-67	49.9	553	8.1	4.5/0.22	0.7/0.06	108/4.70	3.9/0.10	0/0.00	162/2.66	78/1.62	20/0.56	25/0.40		0.5		As=0.04	387		14	0	
Calif. Conservation Center Domestic	29N/13E-4K1	2-15-67	62.0	216	8.0	7.1/0.35	0.4/0.03	34/1.48	9.8/0.25	0/0.00	109/1.79	15/0.31	5.8/0.16	0.5/0.01		0.0		As=0.01	196		19	0	
Zenger Domestic	29N/13E-11P1	2-14-67	58.2	396	8.0					0	208		7.4					As=0.02	275*		47		
George Brabham Domestic	29N/13E-14G1	8-23-66		576										72.0/1.16				As=0.03	400*				
		2-14-67	42.3	799	7.9	18/0.90	8.8/0.72	134/5.83	4.0/0.10	0/0.00	201/3.29	42/0.87	45/1.27	124/2.00		0.1		As=0.02	536		81	0	
Paul E. Milton Domestic	29N/13E-21M1	2-16-67	41.2	460	7.1	36/1.80	18/1.46	22/0.96	1.3/0.03	0/0.00	122/2.00	19/0.40	16/0.45	91/1.47		0.0		As=0.00	348		163	63	
C.L. Curtis Domestic	29N/14E-4N1	8-23-66		870														As=0.02	600*				
		2-15-67	68.0	712	8.3	12/0.60	3.9/0.32	141/6.13	9.5/0.24	0/0.00	333/5.46	54/1.12	22/0.62	5.3/0.08		0.4			461		46	0	

*T.D.S. Computed from Specific Conductance

a. Determined by addition of constituents unless otherwise noted

b. Analysis by indicated laboratory:
U.S. Geological Survey, Quality of Water Branch (U. S. G. S.)
State Department of Water Resources (D. W. R.)

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Owner and use	State well number and other number	Date sampled	Temp in °F	Specific conductance (micromhos at 25° C)	pH	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents	Total[a] dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$ Total ppm	Hardness as $CaCO_3$ N.C. ppm	Analyzed by [b]
						Mineral constituents in parts per million / equivalents per million																	
Bob Piango Irrigation	29N/14E-10E1	7-8-58	59	1520	[illegible].5	13 / 0.65	3.8 / 0.31	327 / 14.22	5.6 / 0.14	16 / 0.53	315 / 5.16	382 / 7.95	54 / 1.52	[illegible] / 0.11	[illegible] / 0.03	[illegible]	[illegible]	Fe 0.02	1030	93	48	0	
		9-8-59	58	1970	8.0	61 / 3.04	16 / 1.30	382 / 16.62	20 / 0.51	0 / 0.00	620 / 10.16	460 / 9.58	75 / 2.12	7.6 / 0.12	0.0 / 0.00	0.60	[illegible]	Fe 0.11 Al 0.08	1390	77	217	0	
	29N/14E-17B1	2-16-67	52.5	752	8.1					0	420		14					As 0.01	510*		201		
Joe Ferre Domestic	29N/14E-17D1	6-12-58	58	530	8.1	14 / 0.70	6.4 / 0.53	138 / 6.00	5.2 / 0.13	0 / 0.00	249 / 4.08	102 / 2.12	44 / 1.24	2.6 / 0.04	0.4 / 0.02	0.46	51	Fe [illegible]	485	82	61	0	
		8-18-67	66.5	1050	8.2					0	426	126	10					As 0.25			58		
		9-29-67																As 0.28					
Marge Duckworth Standish Post Office Domestic	29N/14E-17Q1	8-18-67	65.0	1360	8.2					0	592	118	46					As 2.0			57		
		9-27-67																As 2.6					
Domestic	29N/14E/18P1	8-18-67	61.0	883	8.1					0	314	139	25					As 0.05			326		
Tom Swickard Domestic	29N/14E-18R1	6-12-58	60	900	7.9	21 / 1.05	10 / 0.82	210 / 9.14	9.0 / 0.23	0 / 0.00	427 / 7.00	264 / 5.50	32 / 0.90	14 / 0.23	1.2 / 0.06	0.68	57	Fe 0.00	827	81	94	0	
		9-8-59	-	1050	8.5	20 / 1.00	10 / 0.84	200 / 8.70	6.6 / 0.17	18 / 0.60	311 / 5.10	206 / 4.29	30 / 0.85	2.1 / 0.03	0.8 / 0.04	0.7	28	Fe 0.01 Al 0.09 Zn 0.41 Cu 0.02	675	81	92	0	
		8-23-66		1175												1.1		As 0.35	810*				
		2-14-67	53.5	1420	8.5	9.7 / 0.48	1.2 / 0.10	309 / 13.44	9.0 / 0.23	15 / 0.50	560 / 9.18	162 / 3.37	23 / 0.65	61 / 0.98		1.2		As 0.32	940		29	0	
		8-18-67	60.5		8.0													As 0.30					
		9-27-67																As 0.16					
Edward Grant Domestic	29/N/14E-19A2	6-12-58	54	1500	7.9	28 / 1.40	15 / 1.23	420 / 18.30	3.6 / 0.09	0 / 0.00	479 / 7.85	502 / 10.45	37 / 1.04	90 / 1.45	1.7 / 0.09	1.94	57	Fe 0.00	1386	67	131	0	
		9-8-59	59	1310	8.6	4.4 / 0.22	0.7 / 0.06	292 / 12.70	12 / 0.31	31 / 1.03	457 / 7.49	185 / 3.85	42 / 1.18	2.1 / 0.03	3.0 / 0.16	1.5	10	Cu [illegible] As [illegible] Fe 0.15 Al 0.23	809	96	14	0	
		8-16-67	58.0	1980	8.7			395 / 17.18		25 / 0.83	428 / 7.01	439 / 9.14		133 / 2.14		2.0		As 0.12	1350*		64	0	

* T.D.S. Computed from specific conductance

a. Determined by addition of constituents unless otherwise noted

b. Analysis by indicated laboratory:
U.S. Geological Survey, Quality of Water Branch (U.S.G.S.)
State Department of Water Resources (D.W.R.)

MINERAL ANALYSES OF GROUND WATER

HONEY LAKE VALLEY WATER QUALITY INVESTIGATION

Owner and use	State well number and other number	Date sampled	Temp in °F	Specific conductance (micromhos at 25° C)	pH	Mineral constituents in parts per million / equivalents per million: Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents	Total dissolved solids in ppm[a]	Percent sodium	Hardness as $CaCO_3$ Total ppm	Hardness as $CaCO_3$ N.C. ppm	Analyzed by[b]
M. Rigby Domestic	29N/14E-20B1	8-18-67	66.0	2290	8.2					0	794	332	120					As=0.97			227		
		9-28-67																As=2.0					
Ray Merritt Domestic	29N/14E-20C2	8-18-67	54.0	1390	8.5					13	504	125	56					As=0.57			37		
		9-29-67																As=0.68					
D.J. Ellige Domestic	29N/14E-20G1	8-18-67	60.0	1680	8.2					0	689	192	63					As=0.14			35		
Don Eagle Domestic	29N/14E-20K1	8-18-67	54.2	1280	8.4					4	549	62	20					As=0 05			58		
McClure Ranch Irrigation	29N/14E-28E2	7-9-58	59	1040	8.3	18 / 0.90	6.6 / 0.54	200 / 8.70	9.0 / 0.23	8 / 0.27	350 / 5.74	135 / 2.81	50 / 1.41	3.8 / 0.06	0.6 / 0.03	0.52	56	Fe=0.00	660	84	72	0	
	29N/14E-29J1	8-24-57		563	8.0	16 / 0.80	6.6 / 0.54	89 / 3.87	6.7 / 0.17	0 / 0.00	185 / 3.03	48 / 1.00	51 / 1.44	2.6 / 0.04	0.2 / 0.01	0.19	53		364	72	67	0	
Mapes Ranch Irrigation	29N/15E-18J2	7-8-58	75	3240	8.1	51 / 2.54	7.3 / 0.60	574 / 24.97	22 / 0.56	0 / 0.00	227 / 3.72	295 / 6.14	651 / 18.36	2.8 / 0.04	0.3 / 0.02	0.00	79	Fe=0.04 As=0.02 Al=0.06	1790	87	157	0	
Calif. Dept. of Fish & Game Irrigation	29N/15E-20J1	9-10-59	60	1120	8.8	18 / 0.90	6.8 / 0.56	244 / 10.61	7.2 / 0.18	35 / 1.17	456 / 7.47	83 / 1.73	66 / 1.86	0.7 / 0.01	0.5 / 0.03	0.70	51	Al=0.16 Cu=0.02 Zn=0.01	738	87	73	0	
Calif. Dept. of Fish & Game Irrigation	29N/15E-21N1	11-22-55	52	1060	8.5	6.4 / 0.32	1.9 / 0.16	266 / 11.57	4.0 / 0.10	18 / 0.60	604 / 9.90	35 / 0.73	20 / 0.56	3.4 / 0.05	1.4 / 0.07	0.93	44		699	95	24	0	
		8-24-66		896										0.37	0.4	0.4		Mn=0.07 As=0.00	610*				
		2-15-67	58.1	1140	8.6	4.4 / 0.22	3.4 / 0.28	263 / 11.44	4.2 / 0.11	40 / 1.33	566 / 9.28	47 / 0.98	24 / 0.68	0.7 / 0.01		0.8		As=0.00	710		25	0	
Calif. Dept. of Fish & Game Domestic	29N/15E-21N2	2-15-67	50	1250	9.0					48	481	61						As=0.04	860*		76		
Wendel Hot Spring	29N/15E-23K1	8-8-57	200	1470	8.2	20 / 1.00	0.2 / 0.02	276 / 12.01	8.1 / 0.21	0 / 0.00	51 / 0.84	342 / 7.12	192 / 5.41	0.0 / 0.00	2.2 / 0.12	5.1	53	Fe=0.04 Al=0.06 As=0.18	924	91	51	9	
		2-15-67	120	1490	8.5	22 / 1.00	0.0	285 / 12.40	0.0	9 / 0.30	35 / 0.57	366 / 7.62	182 / 5.13	0.3 / 0.00		4.8		Al=0.00 Pb=0.00 As=0.22 Mn=0.00 Fe=0.01 Zn=0.00 Cu=0.00	1010		50	21	
Spring	29N/15E-24F1	7-8-58	88	368	8.2	17 / 0.85	2.1 / 0.17	49 / 2.13	7.2 / 0.18	0 / 0.00	144 / 2.36	29 / 0.60	15 / 0.42	2.2 / 0.04	0.1 / 0.00	0.17	40	Fe=0.14 Al=0.28 As=0.02	239	64	51	0	
Frank Dewitt Domestic	29N/15E-30A2	8-24-66		589														Mn=0.07 Pb=0.00 As=0.06	400*				
		2-16-67	54.2	617	8.5	12 / 0.60	3.2 / 0.26	129 / 5.61	4.2 / 0.11	9 / 0.30	365 / 5.98	11 / 0.23	7.0 / 0.20	0.5 / 0.01		0.4		As=0.05	377		43	0	
*T.D.S. Computed from Specific Conductance																							

a. Determined by addition of constituents unless otherwise noted

b. Analysis by indicated laboratory:
U.S. Geological Survey, Quality of Water Branch (U.S.G.S.)
State Department of Water Resources (D.W.R.)

MINERAL ANALYSES OF GROUND WATER

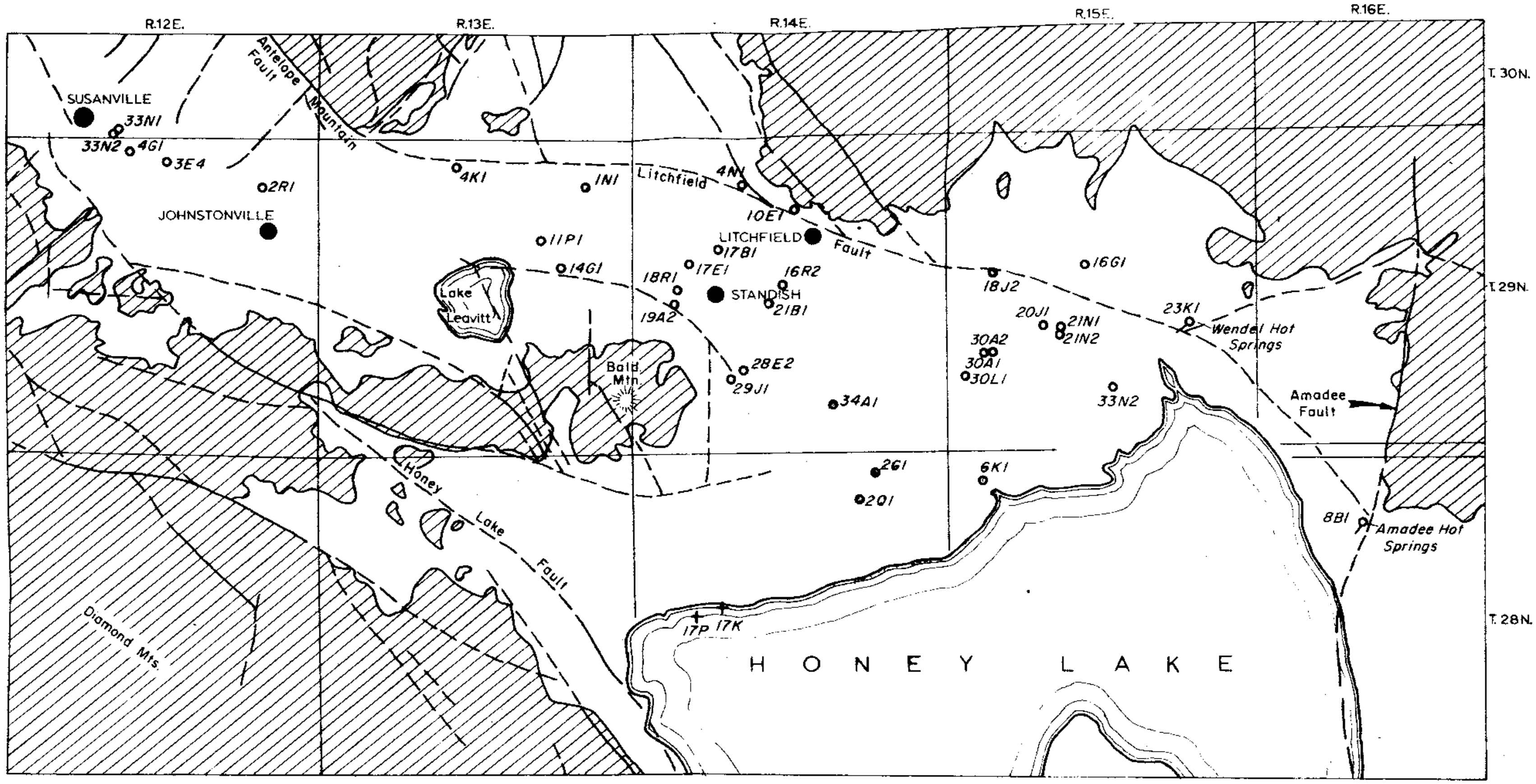
HONEY LAKE VALLEY WATER QUALITY INVESTIGATION

Owner and use	State well number and other number	Date sampled	Temp in °F	Specific conductance (micromhos at 25° C)	pH	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents	Total[a] dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$ Total ppm	Hardness as $CaCO_3$ N.C. ppm	Analyzed by[b]
						Mineral constituents in parts per million / equivalents per million																	
Southern Pacific Railroad Domestic - Irrigation	29N/16E-30L1	2-15-67	83.3	316	8.2					0	114	18						As=0.00	210*		25		
Calif. Pacific Utilities Company Industrial	30N/12E-33N1	7-9-58	63	505	8.2	29 1.45	15 1.23	49 2.13	4.0 0.10	0 0.00	148 2.42	73 1.52	33 0.93	6.1 0.10	0.6 0.03	0.37	45	Fe=0.06	328	43	134	13	
Calif. Pacific Utilities Company Industrial	30N/12E-33N2	7-9-58	72	544	7.9	20 1.00	6.8 0.56	80 3.48	3.6 3.48	0 0.00	97 1.59	111 2.31	41 1.16	1.0 0.02	0.9 0.05	0.76	44	Fe=0.00	357	68	78	0	
		2-14-67	49.5	185						0 0.00	116		2.1					As=0.00	120*		80		

*T.D.S. Computed from Specific Conductance

a. Determined by addition of constituents unless otherwise noted

b. Analysis by indicated laboratory:
U.S. Geological Survey, Quality of Water Branch (U. S. G. S.)
State Department of Water Resources (D. W. R.)



LEGEND

- Fault
- Concealed or Probable Fault
- Water Quality Problem Well
- Surface Water Sample
- Alluvial Valley Deposits
- Intrusive Rocks

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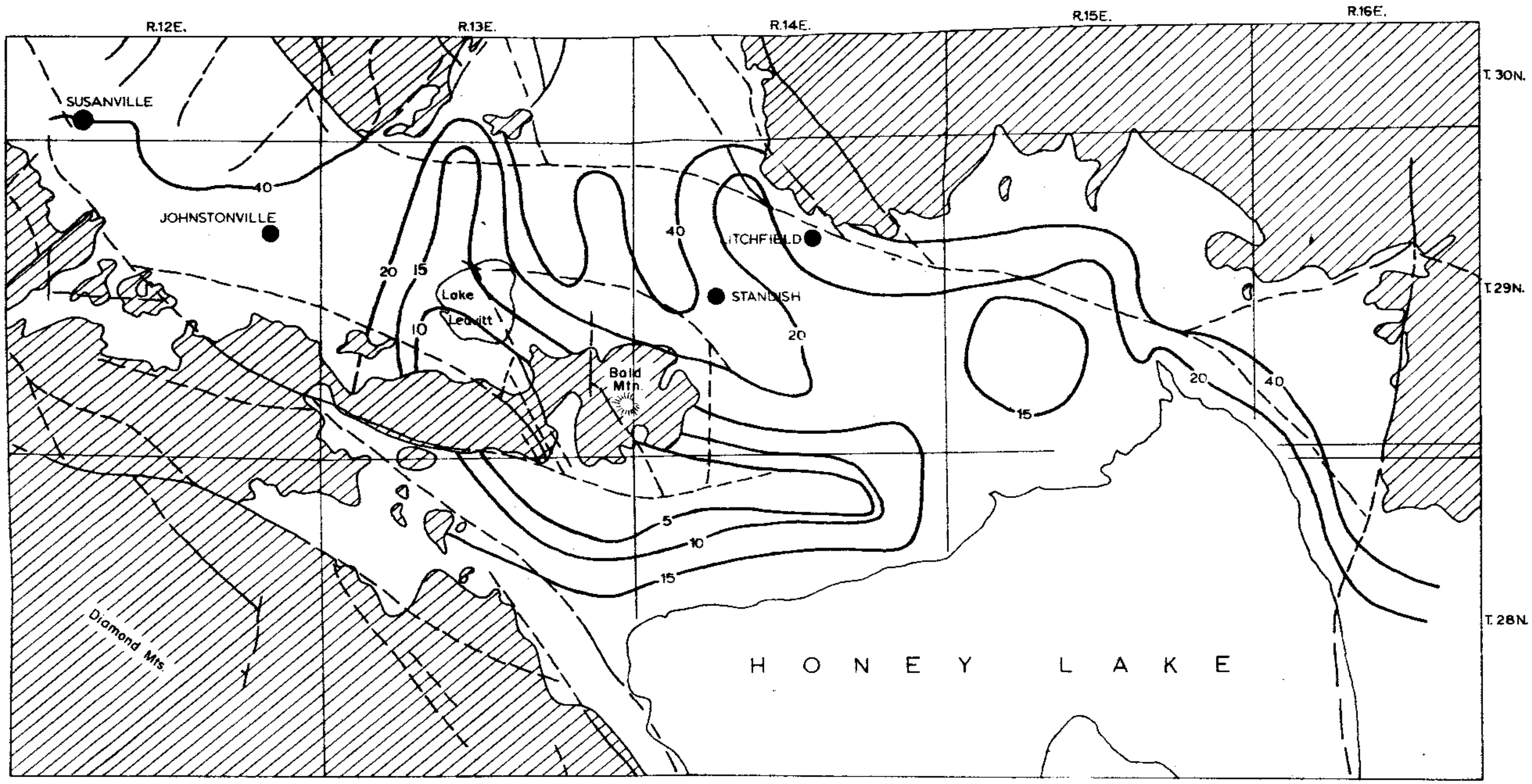
NORTHERN DISTRICT

HONEY LAKE VALLEY
WATER QUALITY INVESTIGATION
GEOLOGY



LEGEND

FAULT
INTRUSIVE ROCKS
CONCEALED OR PROBABLE FAULT
20 SULFATES % REACTANCE VALUE CONTOURS

scale of miles
1 0 1 2

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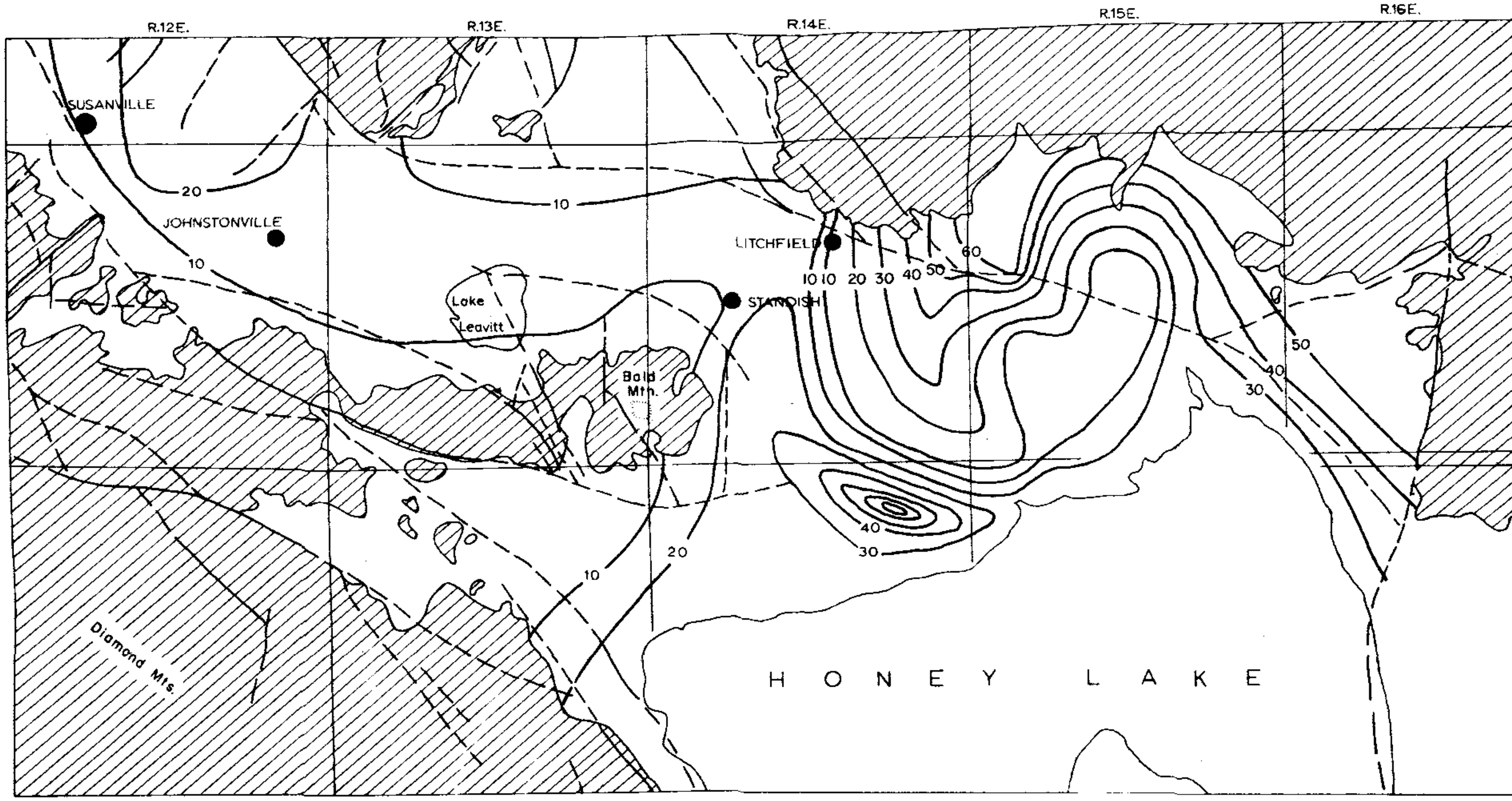
HONEY LAKE VALLEY
WATER QUALITY INVESTIGATION

SULFATE CONTOURS



LEGEND

FAULT

INTRUSIVE ROCKS

CONCEALED OR PROBABLE FAULT

—10— CHLORIDES % REACTANCE VALUE CONTOURS

scale of miles

1 0 1 2

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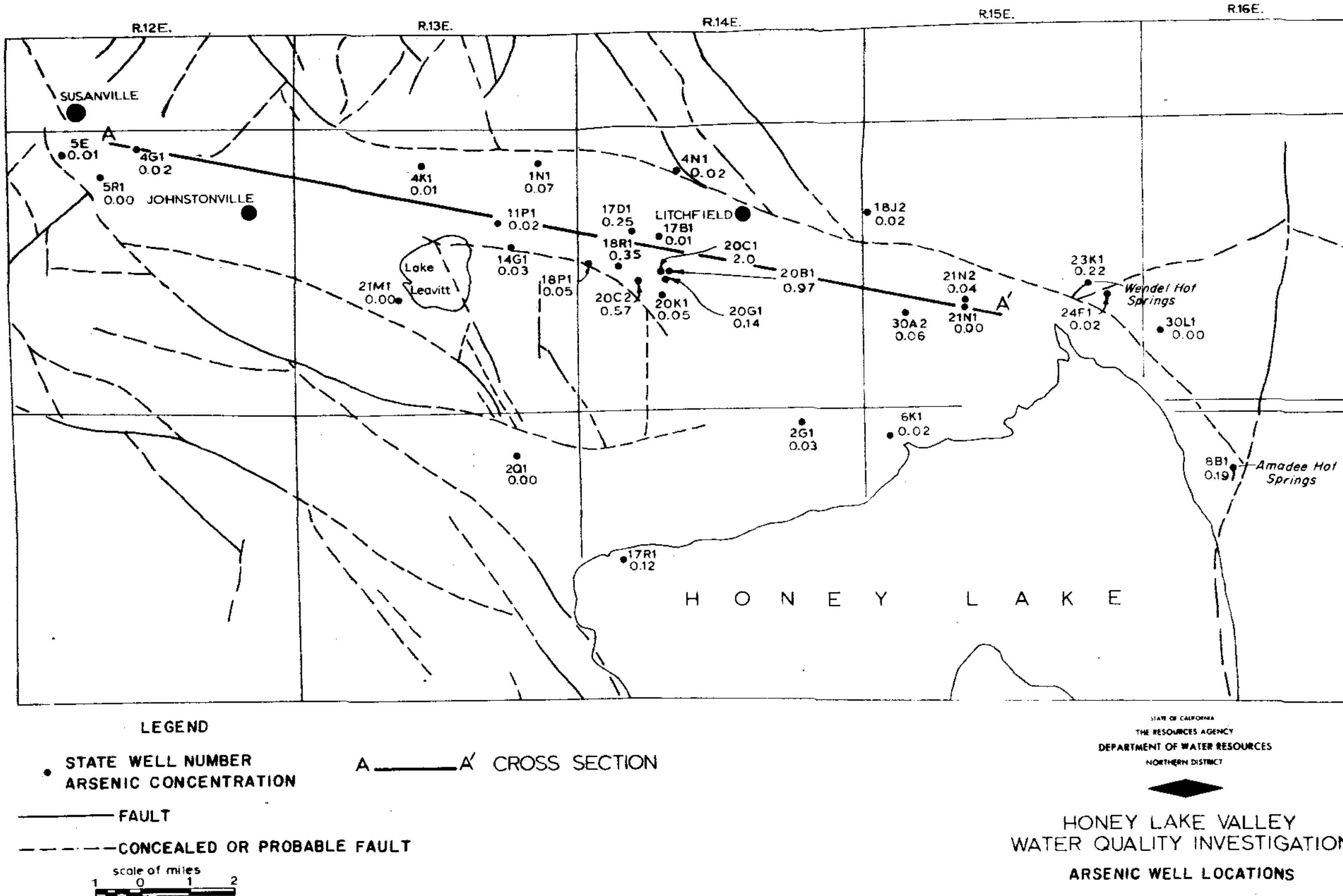
HONEY LAKE VALLEY
WATER QUALITY INVESTIGATION
CHLORIDE CONTOURS



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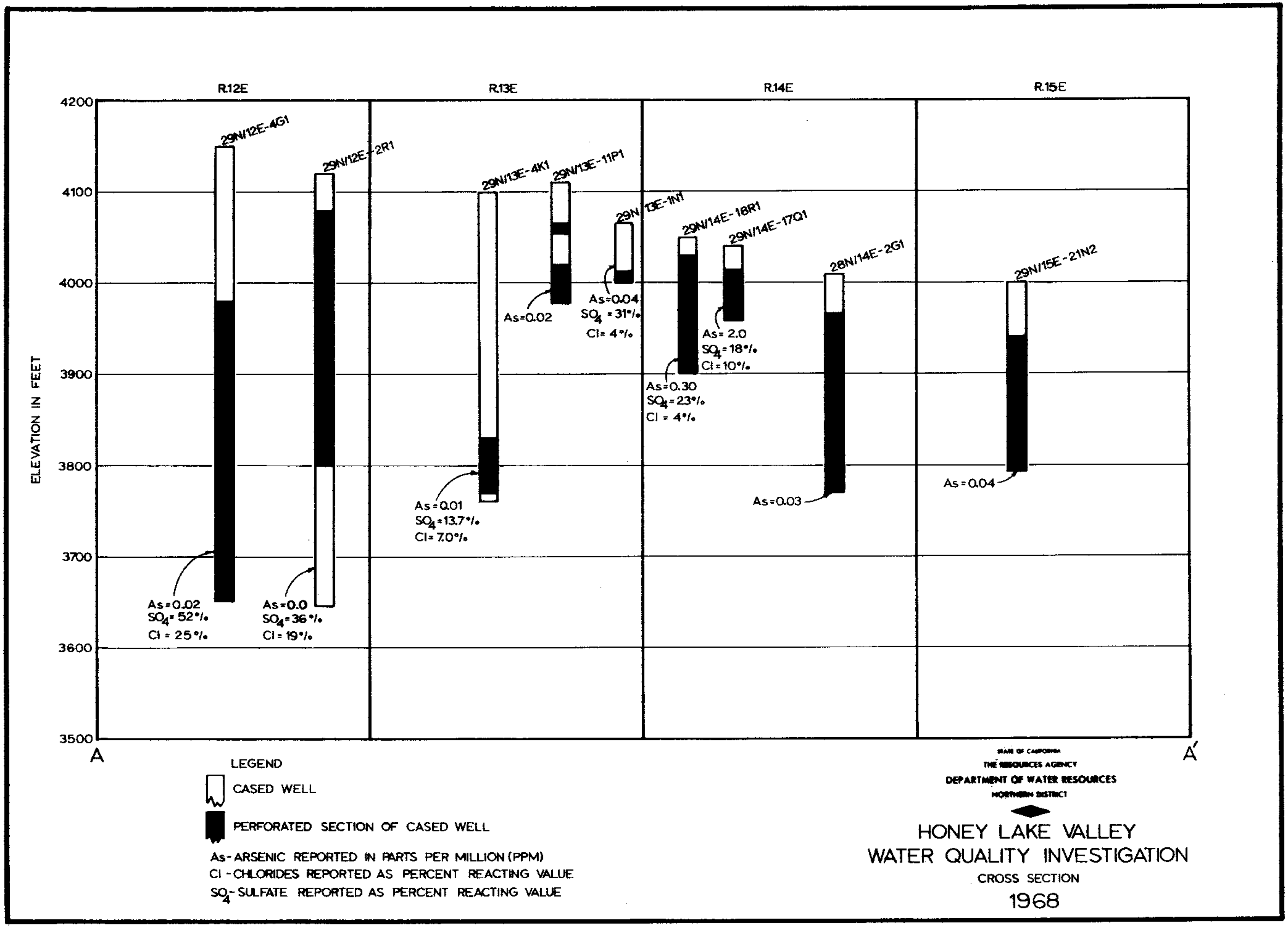
HONEY LAKE VALLEY
WATER QUALITY INVESTIGATION

ARSENIC WELL LOCATIONS

PLATE 5


R.12E
R.13E
R.14E
R.15E
ELEVATION IN FEET
4200
4100
4000
3900
3800
3700
3600
3500
A
A′
29N/12E-4G1
29N/12E-2R1
29N/13E-4K1
29N/13E-11P1
29N/13E-1N1
29N/14E-18R1
29N/14E-17Q1
28N/14E-2G1
29N/15E-21N2
As=0.02
SO4=52%
Cl=25%
As=0.0
SO4=36%
Cl=19%
As=0.01
SO4=13.7%
Cl=7.0%
As=0.02
As=0.04
SO4=31%
Cl=4%
As=0.30
SO4=23%
Cl=4%
As=2.0
SO4=18%
Cl=10%
As=0.03
As=0.04
LEGEND
CASED WELL
PERFORATED SECTION OF CASED WELL
As-ARSENIC REPORTED IN PARTS PER MILLION (PPM)
Cl-CHLORIDES REPORTED AS PERCENT REACTING VALUE
SO4-SULFATE REPORTED AS PERCENT REACTING VALUE
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HONEY LAKE VALLEY
WATER QUALITY INVESTIGATION
CROSS SECTION
1968